PANDA-X
A New Detector for Dark Matter Search

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Seminar at KEK, Tsukuba Japan
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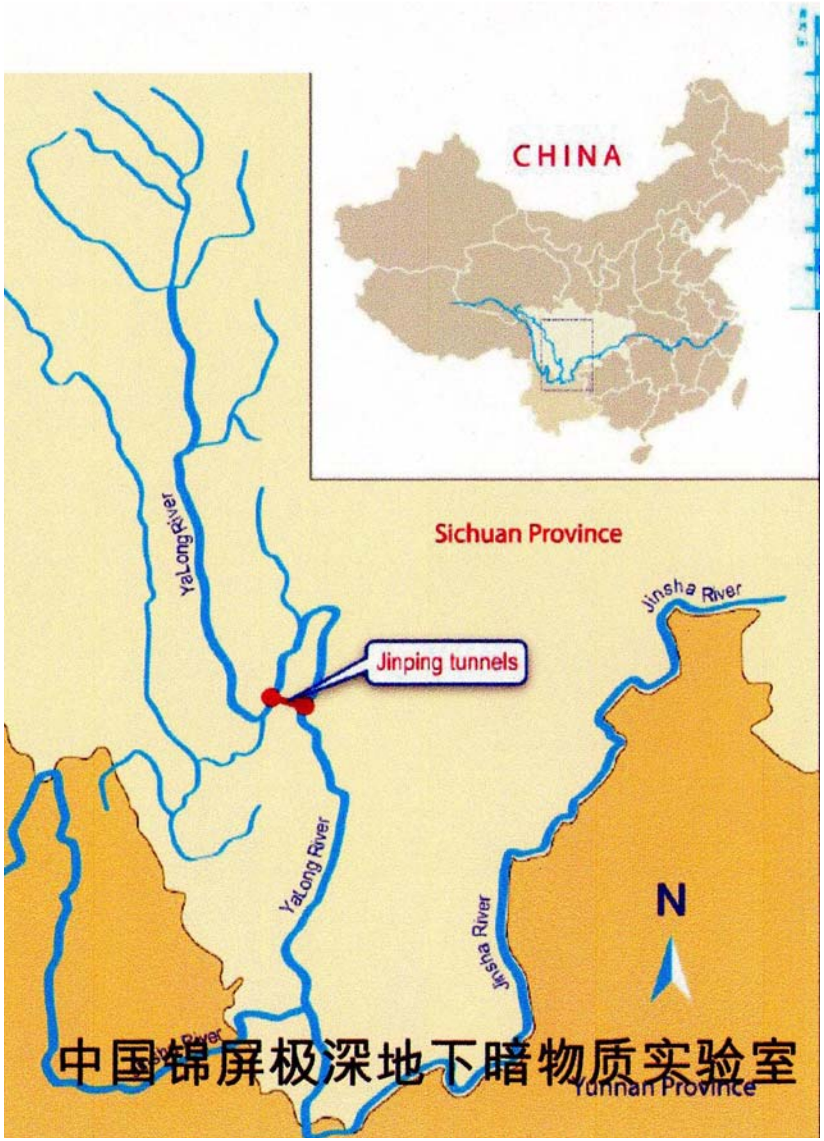
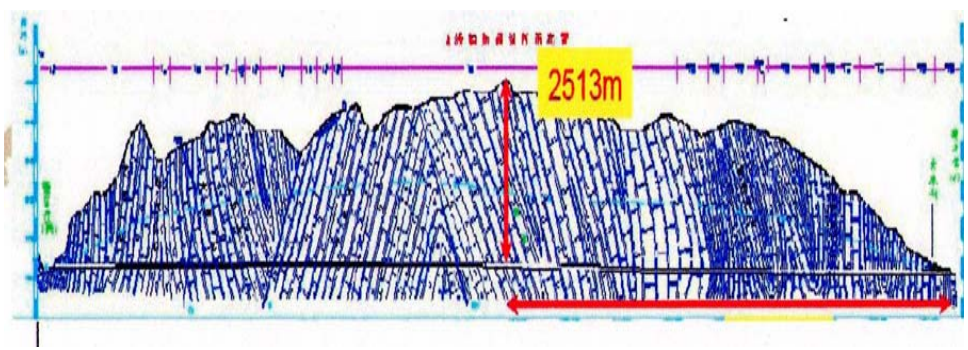
PANDA-X　Dark Matter Search



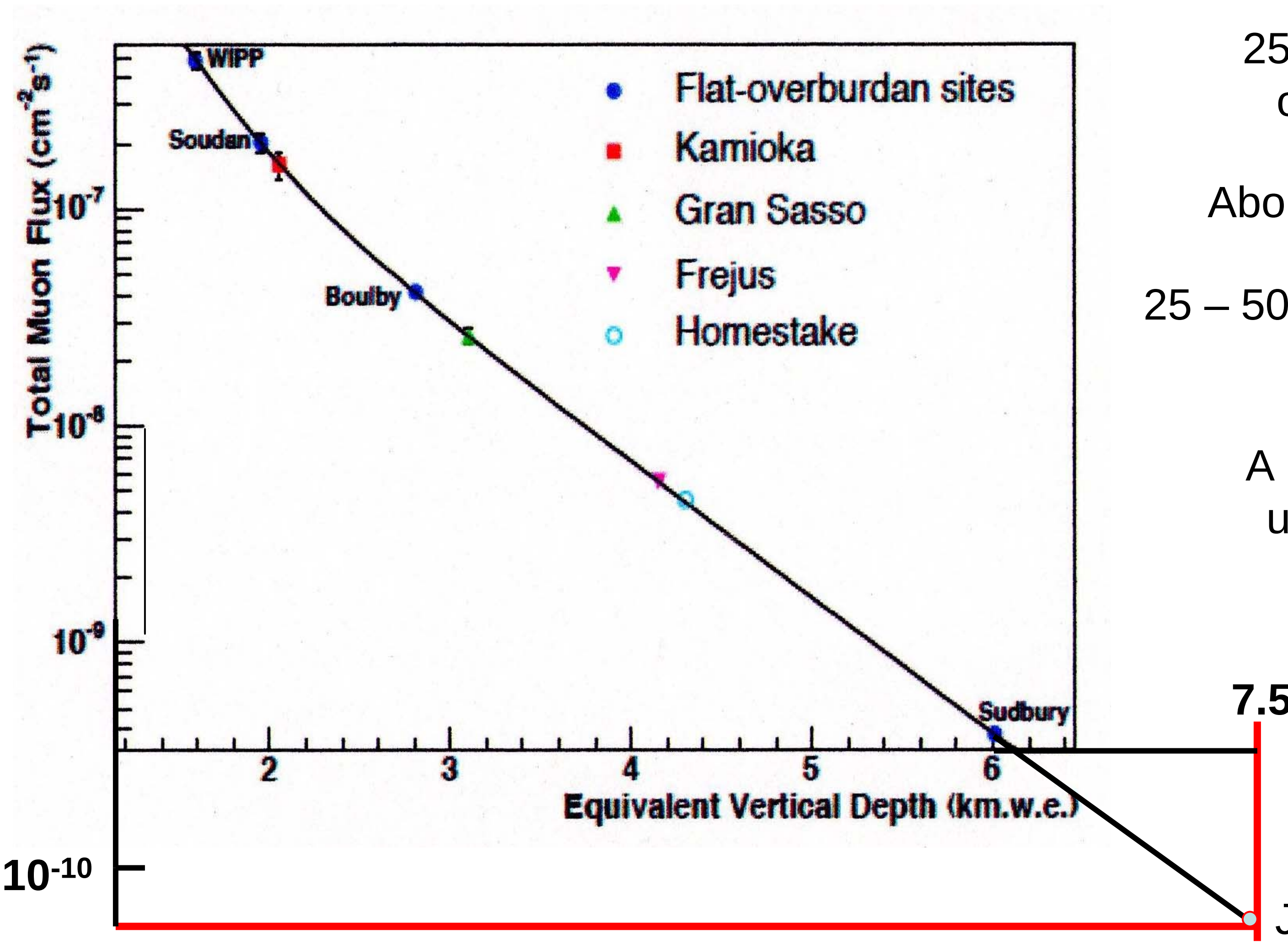
Jin Ping Laboratory

Newly constructed deep underground lab In the south of China, Sichuan Province

Now available for installation of detectors



PANDA-X Dark Matter Search



2500 m of rock overburden

About 7500 m.w.e.

25 – 50 Muons per year

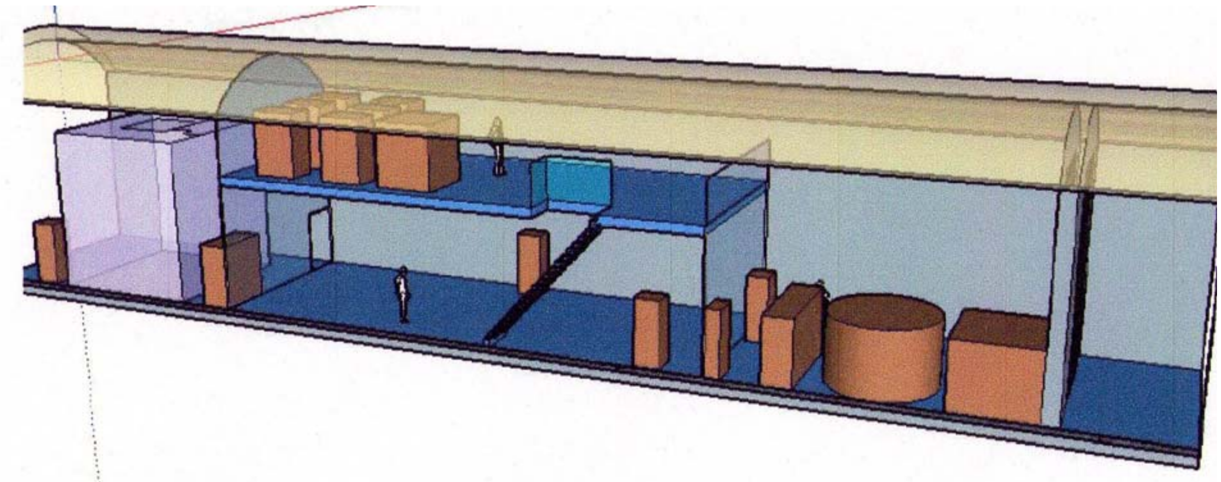
A muon veto is unnecessary

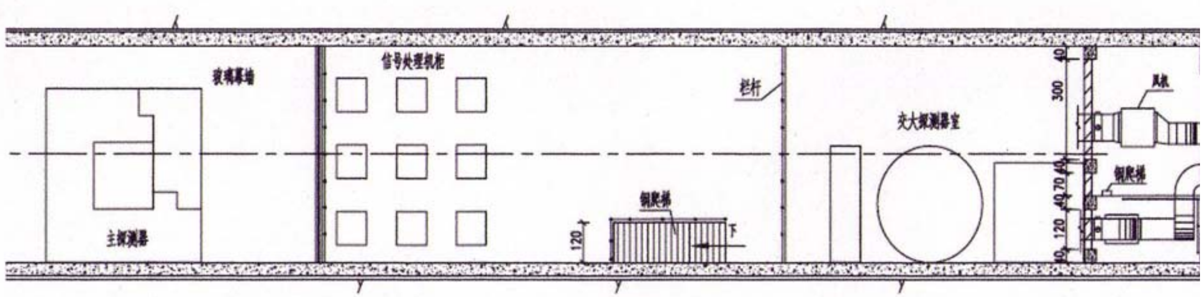
25 – 50 Muons per year

PANDA-X   Dark Matter Search

The lab was designed and built by Tsinghua University, Beijing and ERTAN power company

The lab is 40 m x 7 m and 6.5 m high.





PANDA – X will occupy the last 10 m, but we must leave half the width for trucks to pass.

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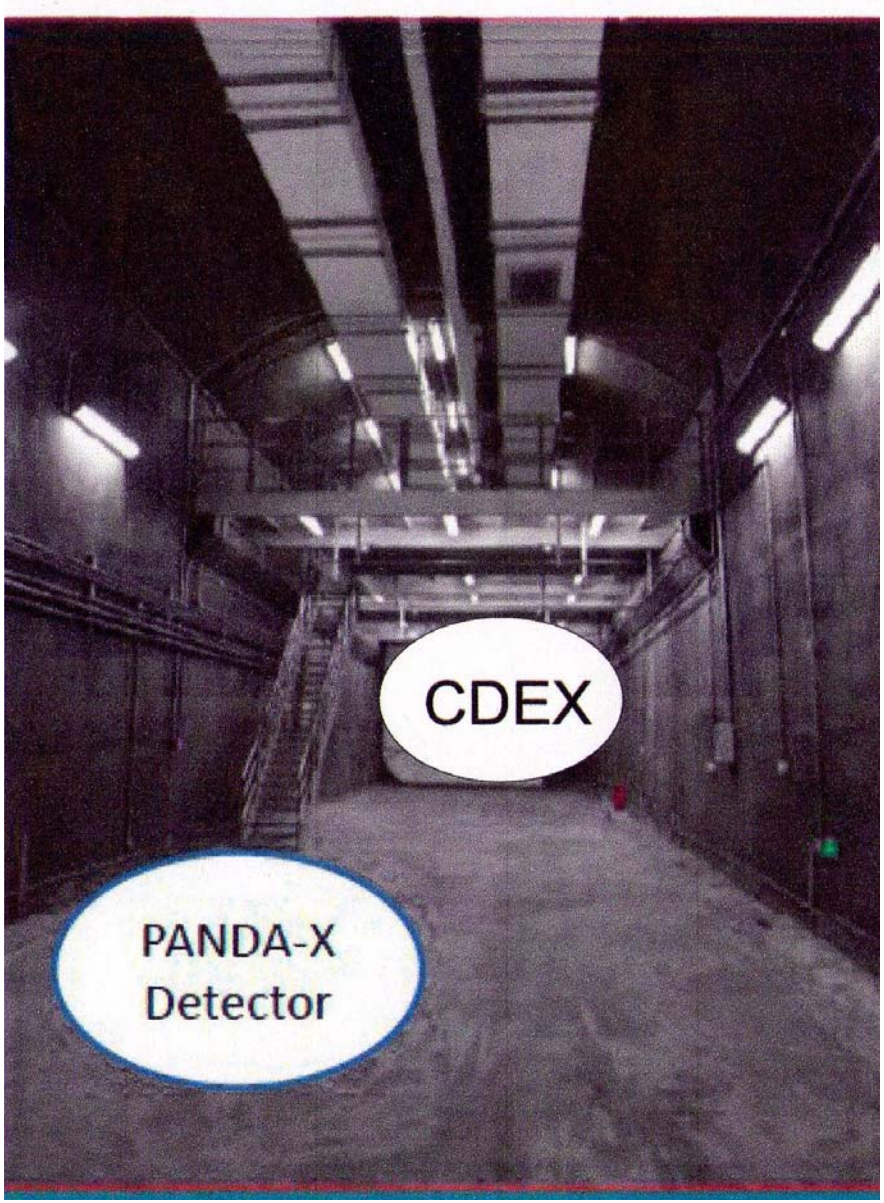


PANDA will have a passive shield in the classical form of

5 cm OFHC copper
20 cm polyethylene
20 cm lead
40 cm polyethylene

In an octogonal shape.

No active shield!
No water shield!
No muon veto shield!

The innermost 5 cm of copper form a hermetic cylinder of 1.35 m diameter and 1.85 m height.

This is also the outer vessel of the vacuum cryostat

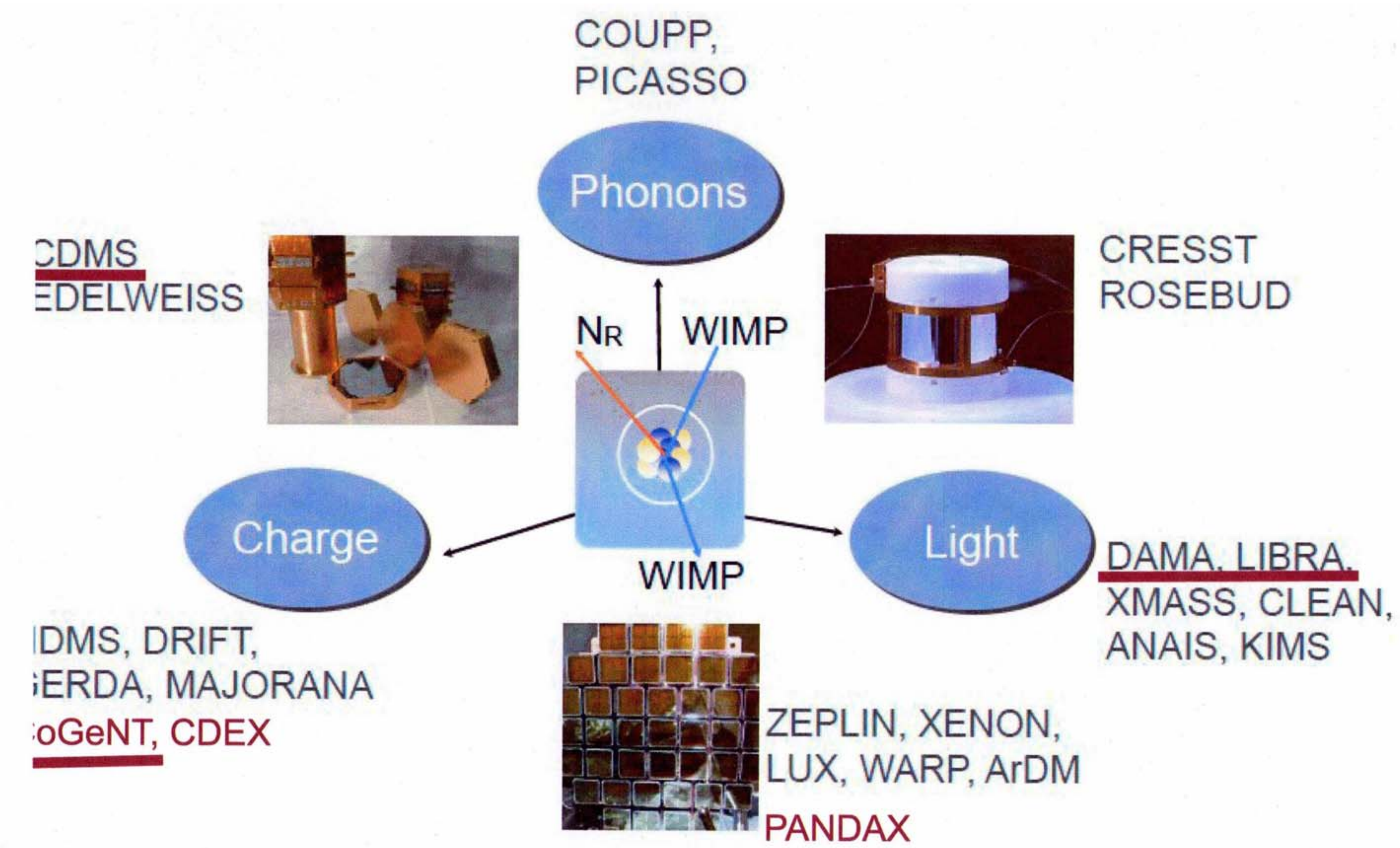
PANDA-X Dark Matter Search

Originally PANDA was intended to be a complement of the XENON100 detector. However, before the design started the liaison was cut, and the design in nearly all details is entirely different and fully developed at Jiao Tong.

The Panda team:

PANDA-X Dark Matter Search

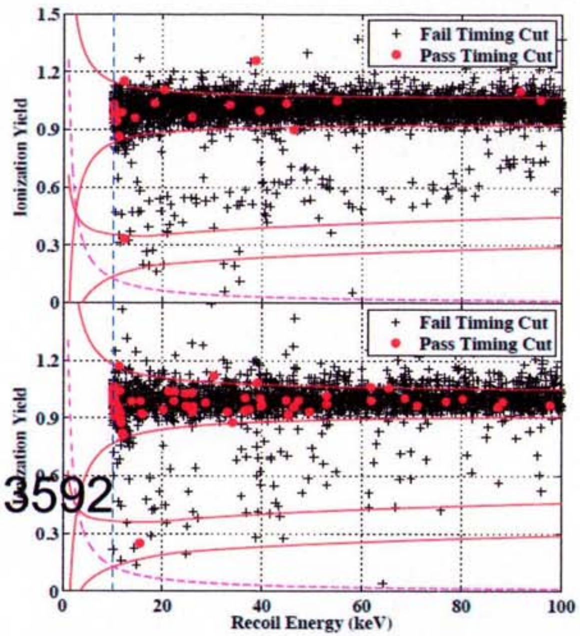
Direct detection of Dark Matter (WIMPs)

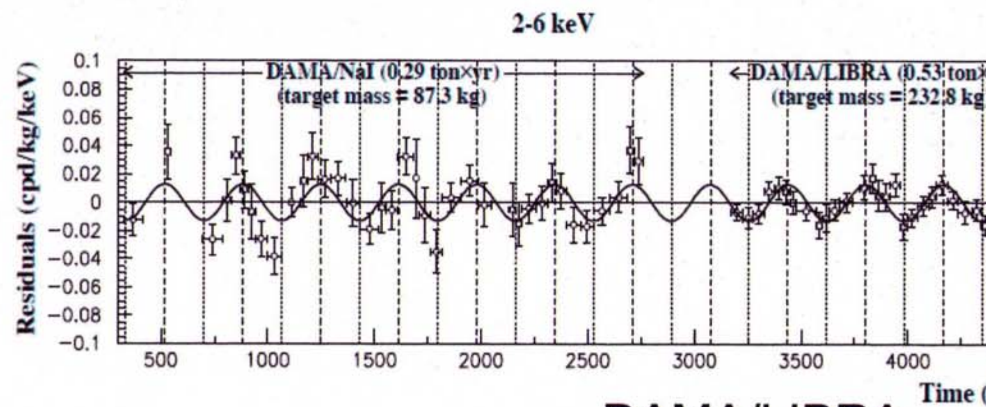


PANDA-X Dark Matter Search

DMS

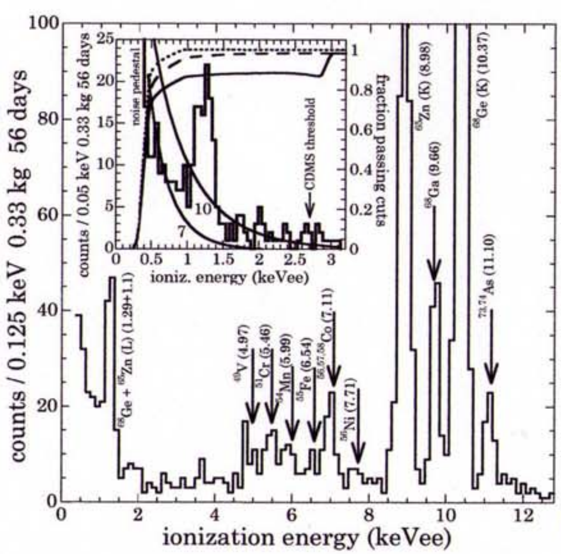
Xiv:0912.3592



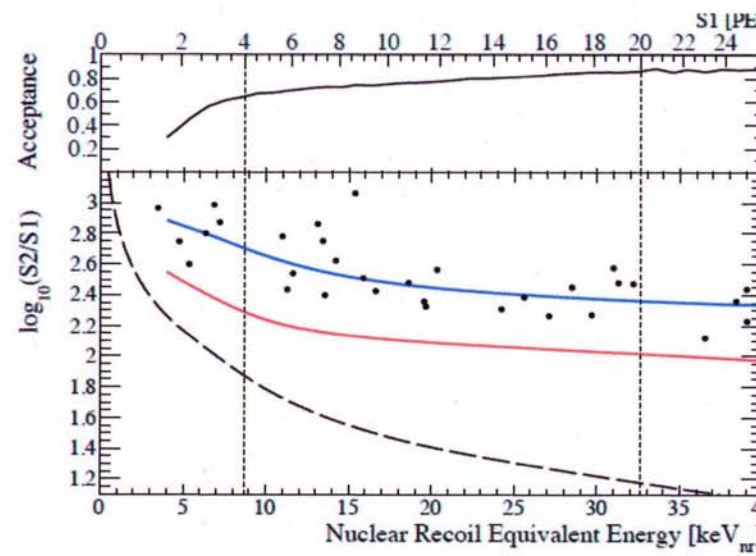


DAMA/LIBRA

oGeNT



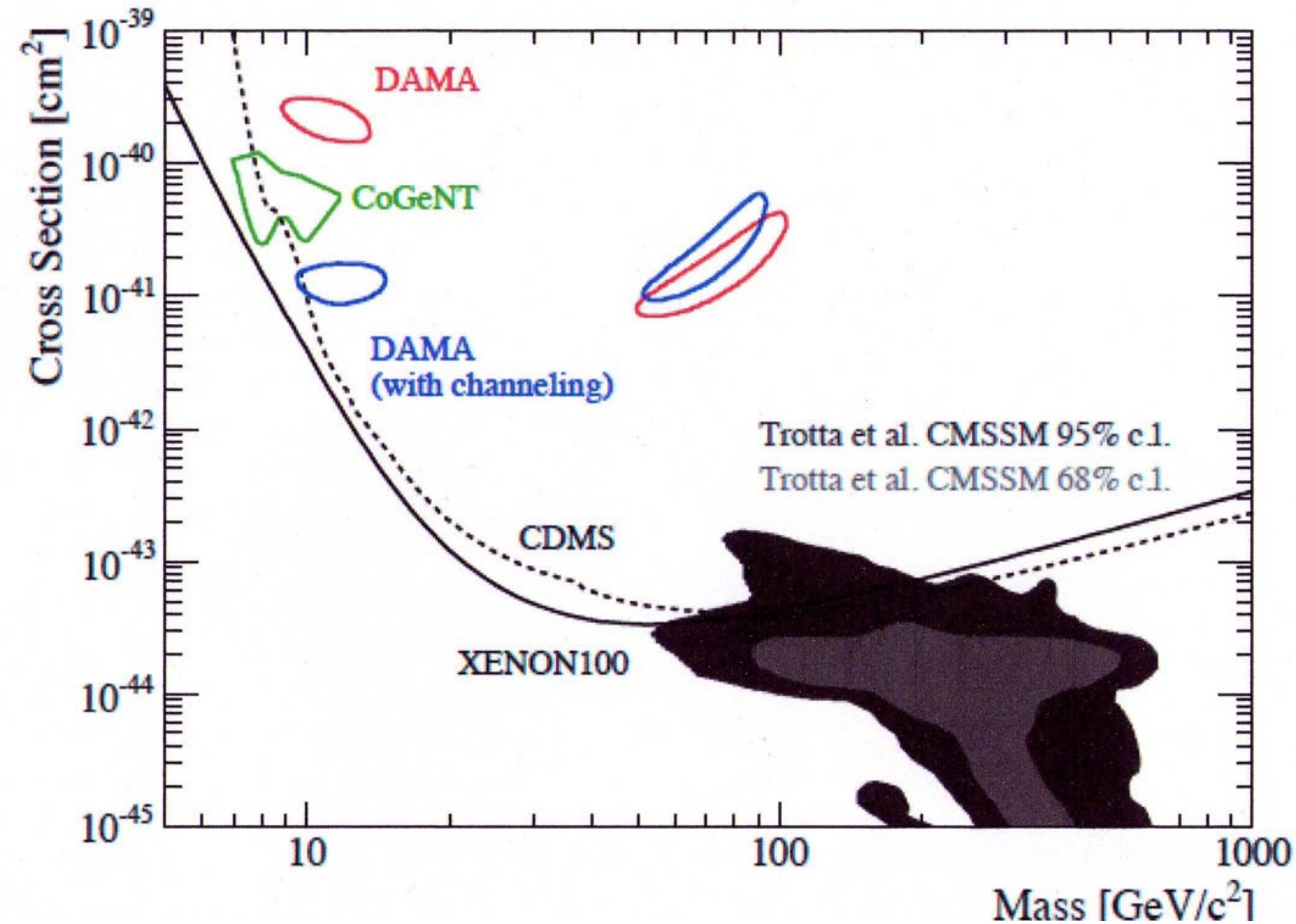
arXiv:1002.4703



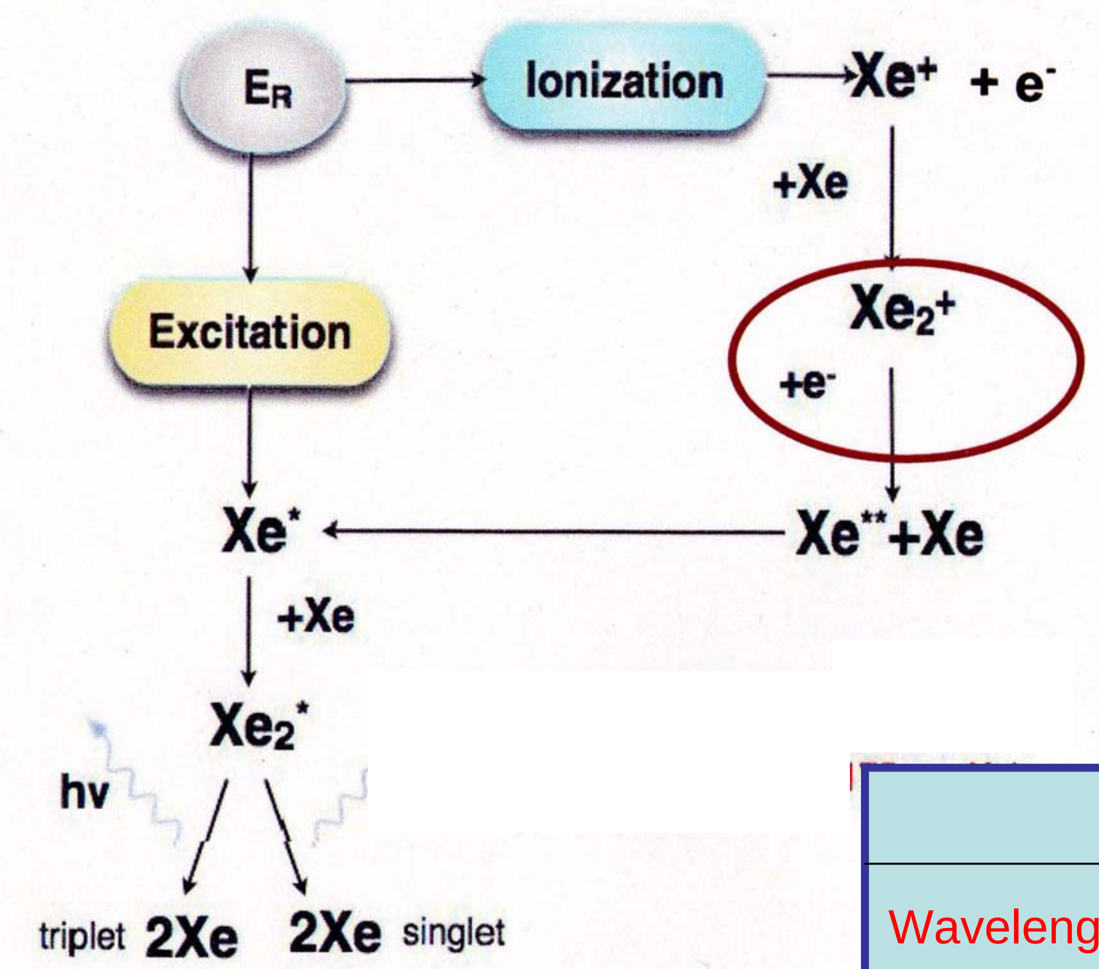
XENON100 arXiv:1005.0380

PANDA-X Dark Matter Search

Overview of present results



PANDA-X Dark Matter Search



Charge and light yield depend on Ionisation density

		Ne	Ar	Xe
Wavelength	nm	85	128	175
Fast Light	nsec	few	10	3
Slow Light	µsec	15.4	1.5	27

PANDA-X Dark Matter Search

Advantages of Liquid Xenon

High Density (3 g/cm^3)

Large Atomic Number (σ_{si} prop. A^2)

Spin Independent + Dependent (^{131}Xe)

Easy Scale up to Large Detector Mass

No Long-Lived Radioactive Isotopes

Efficient Scintillator (80 % of NaI(Tl))

No Wavelength Shifter (178 nm)

Transparent to Scintillation Light

Dielectric Strength >few 10^5 V/cm

Charge depends on Ionization Density

Problems of Xenon

Cryogenic (-100° C)

^{85}Kr contamination

VUV light

Expensive

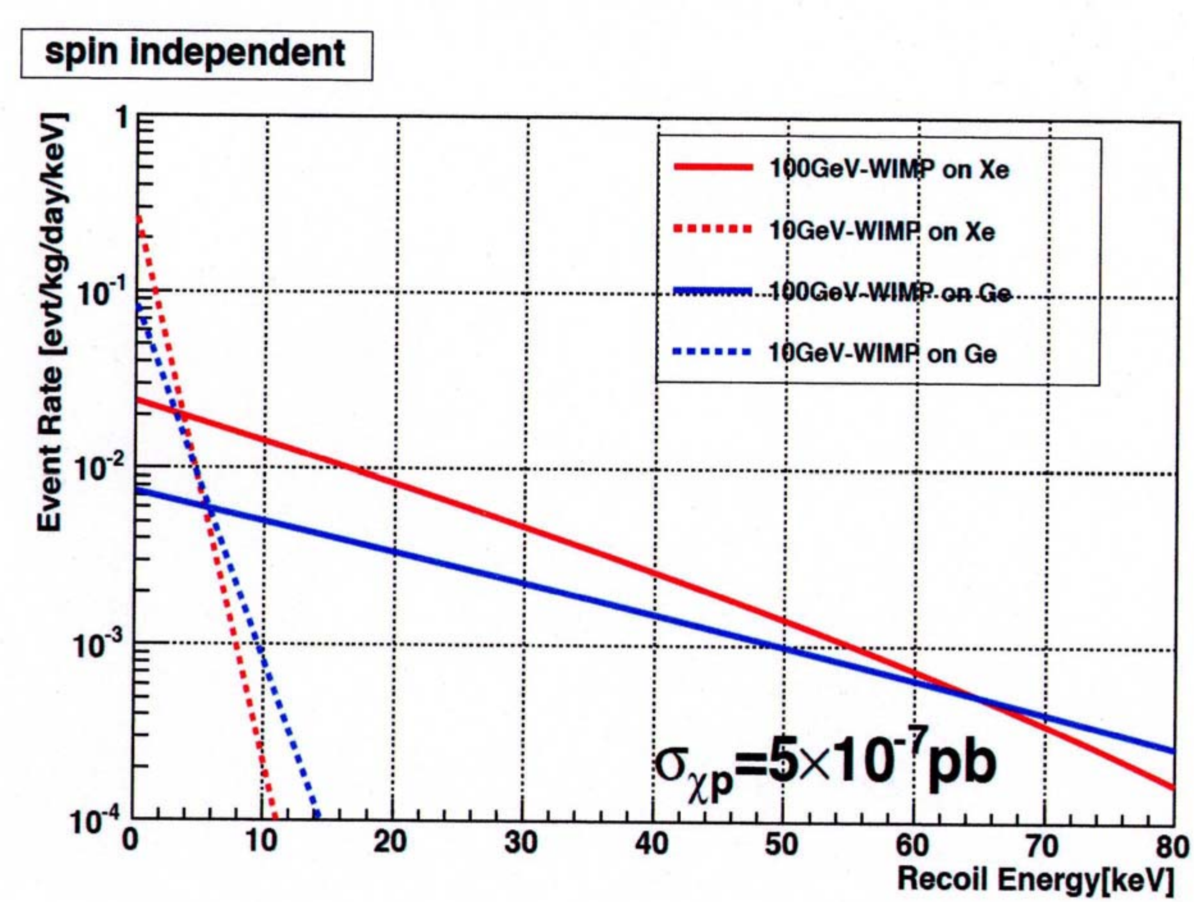
Technologies which make large detectors posssible

PTR – Cooling	low maintenance, reliable, stability
VUV - PMTs	optimized for Xe, high Q_e, low T, high P, low RI, fast
Recirculation – Purification	electron drift times > msec
Dual Phase	Charge measurement with proportional scintillation
Liquid Distillation	Kr removal
Combined Charge - Light Signal	very good energy resolution

PANDA-X Dark Matter Search

WIMP Detection Challenge: Background Discrimination

Signal: < 0.1 /kg/day (background 106 /kg/day
< 100 keV
point like, no other feature



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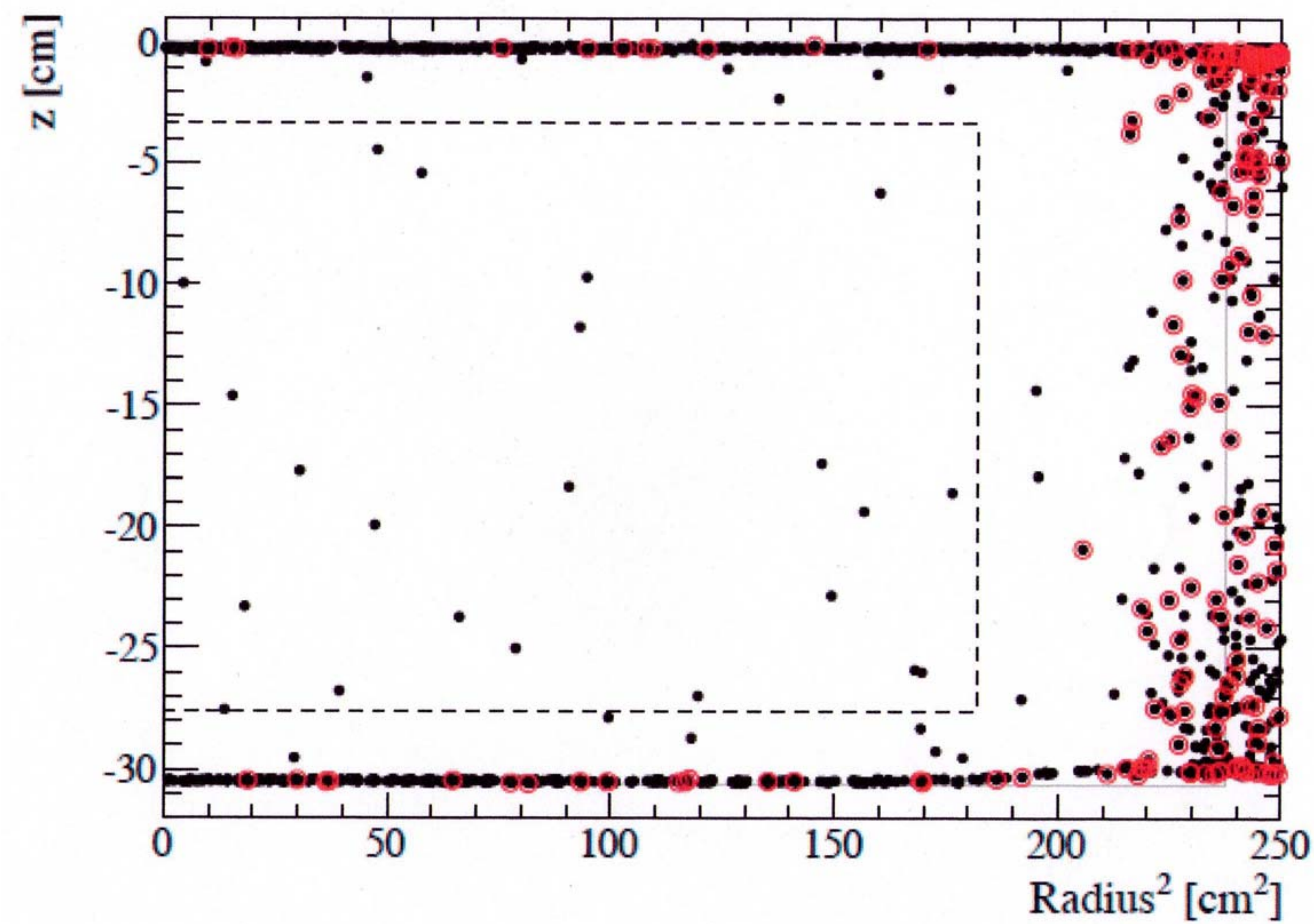
Self – shielding effect can be easily seen in data from XENON100(arXiv1005.0380)



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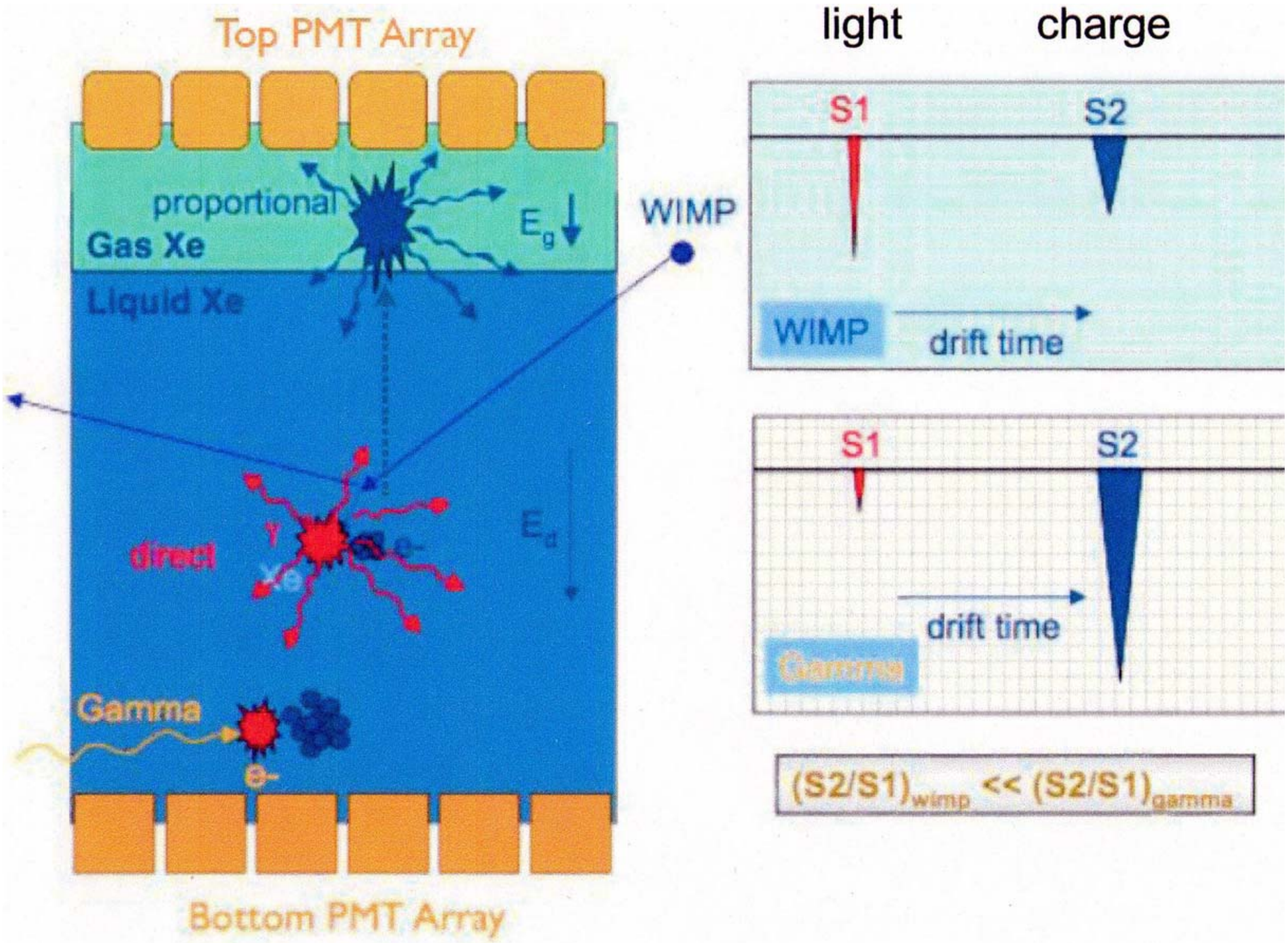
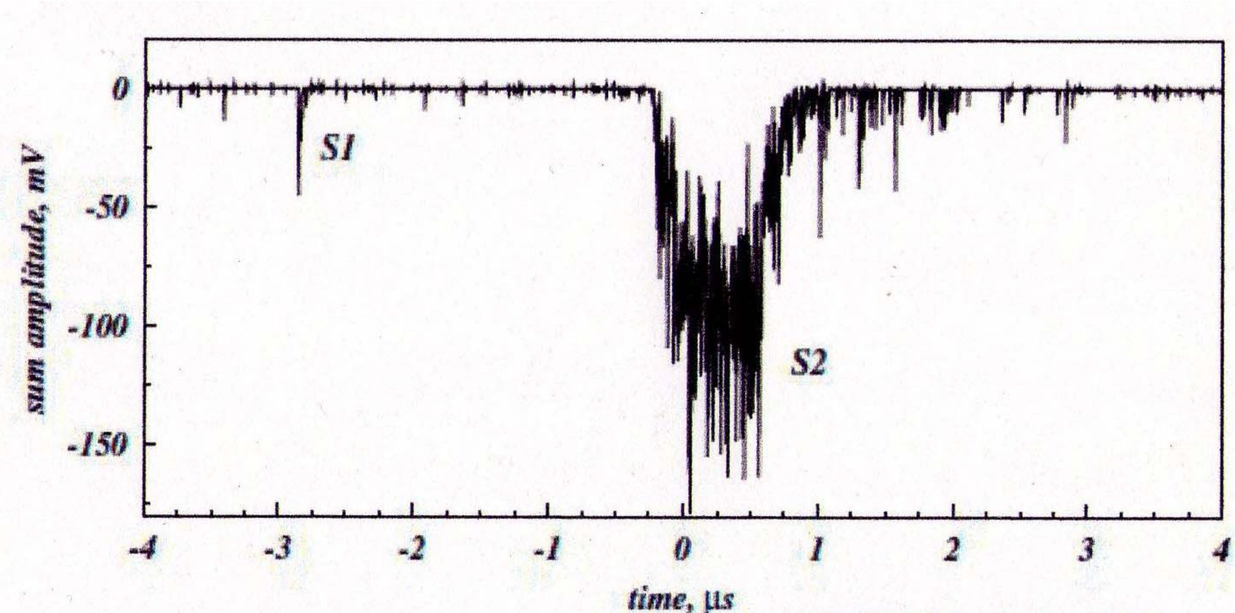
Additional Background discrimination by light and charge collection



PANDA-X Dark Matter Search



(ZEPLIN-III)

Amplification of s2 ≈ 100

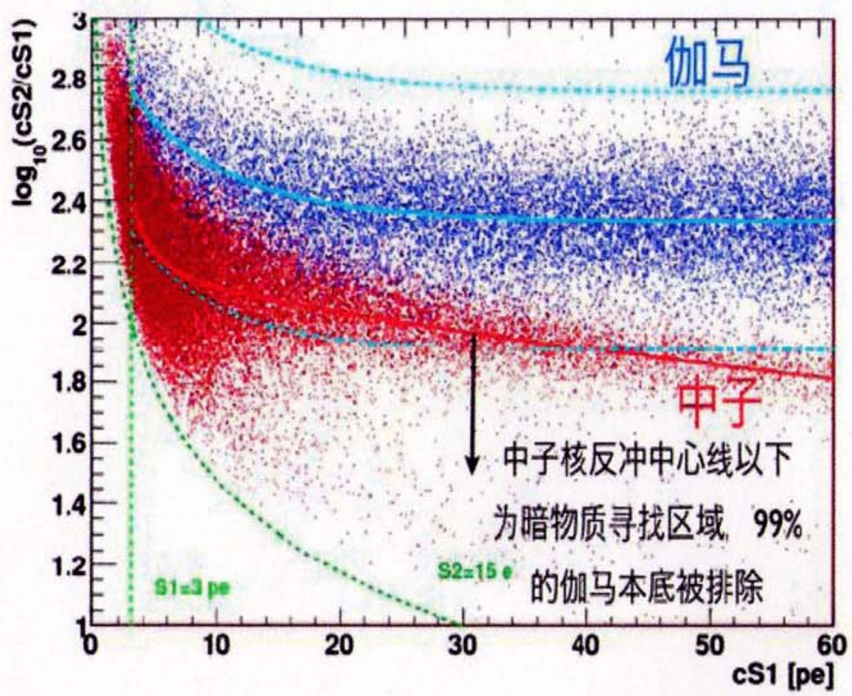
Enhanced discrimination due to Gamma – Neutron Band separation
Better position resolution (double hit resolution)
Less fiducial volume cut required

But:

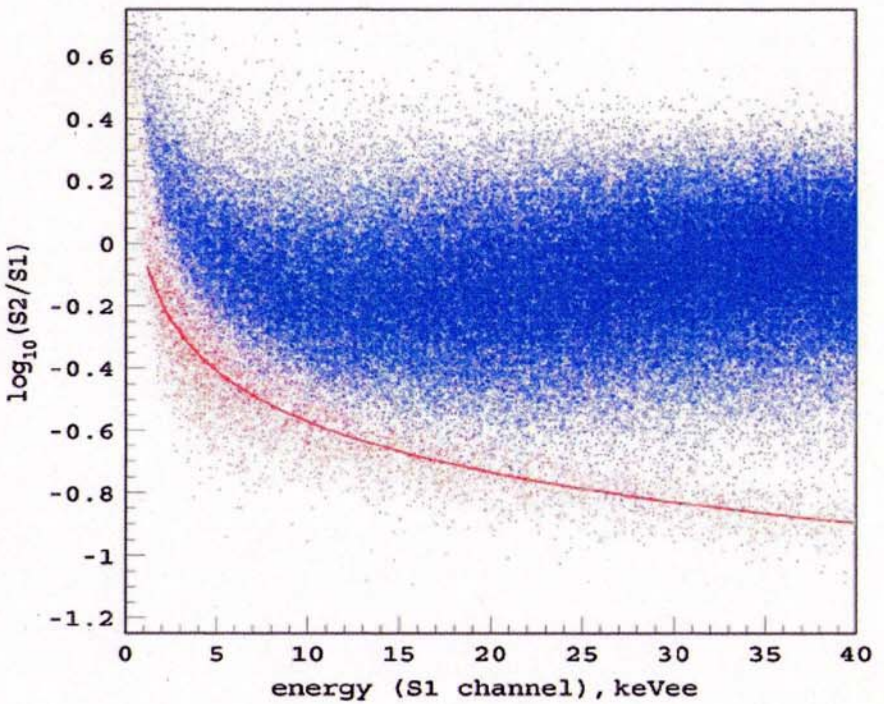
Large area grids	Precise level contol
HV feedthroughs	Grids must be leveled (parallel to liquid surface)
High electric field in gas space	Large dead time
	Large amount of digitizer data

PANDA-X Dark Matter Search

Higher drift field enhances the Gamma – Neutron band separation



XENON100 E_{drift}=0.5kV/cm
99% gamma rejected

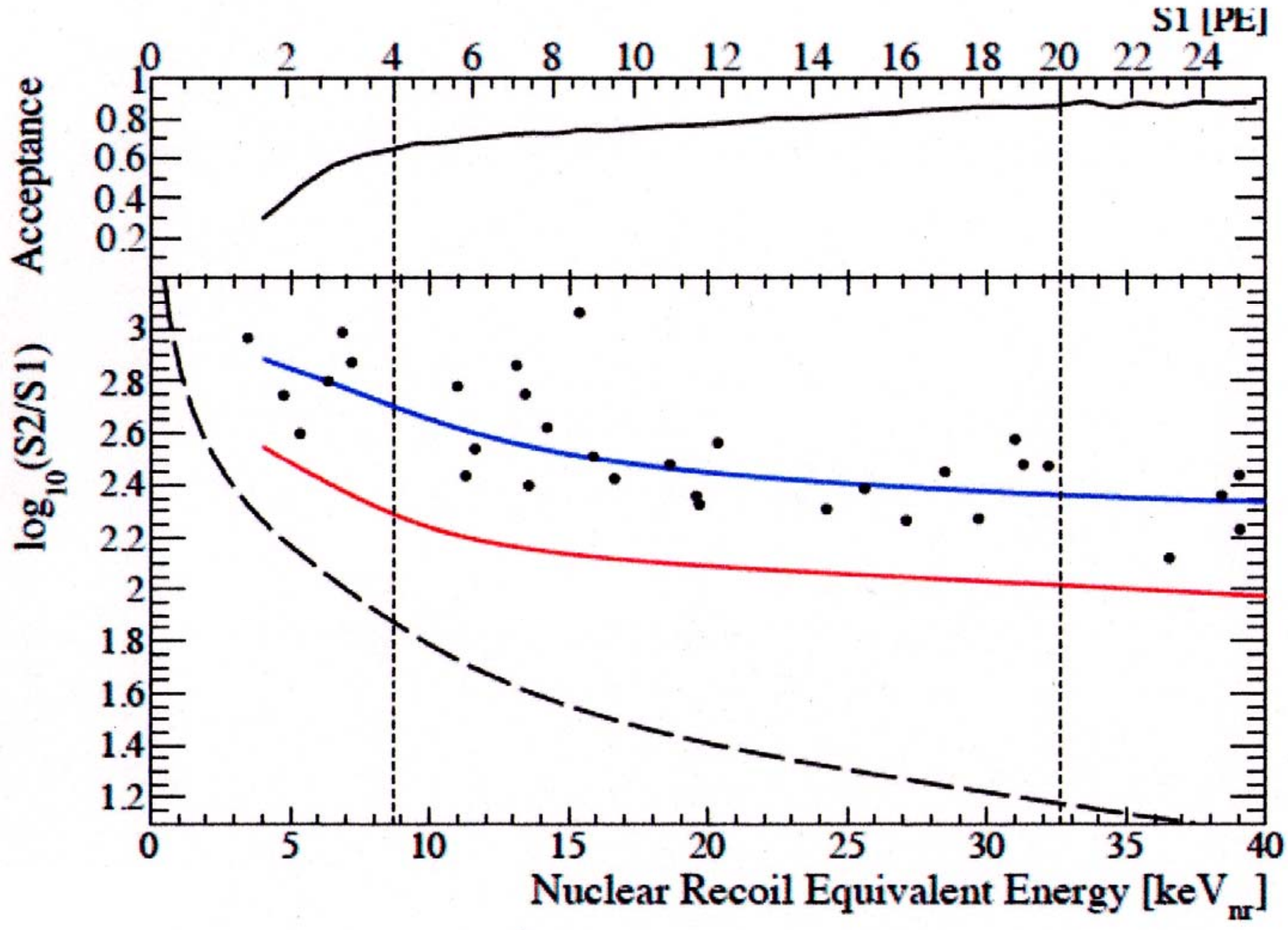


ZEPLIN-III E_{drift}=3.9kV/cm
99.9% gamma rejected

PRD 80, 052010 (2009)

PANDA-X Dark Matter Search

Example from XENON100: All 22 events in fiducial volume
failed S2/S1 and single hit cut



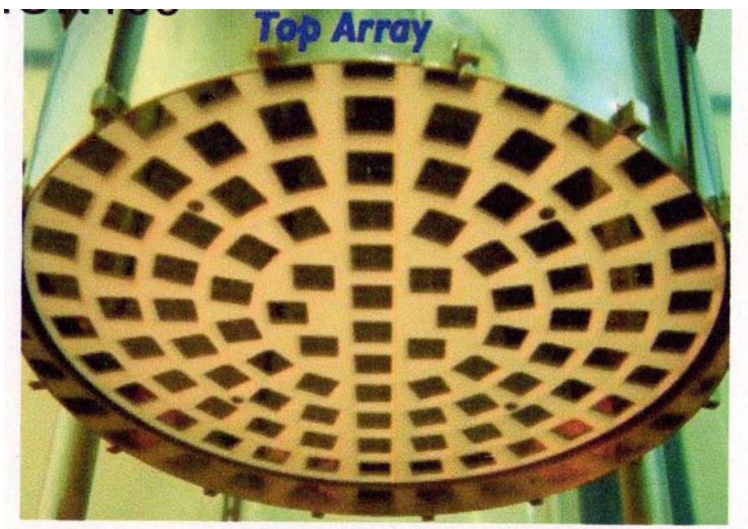
XENON100
arXiv1005.0380

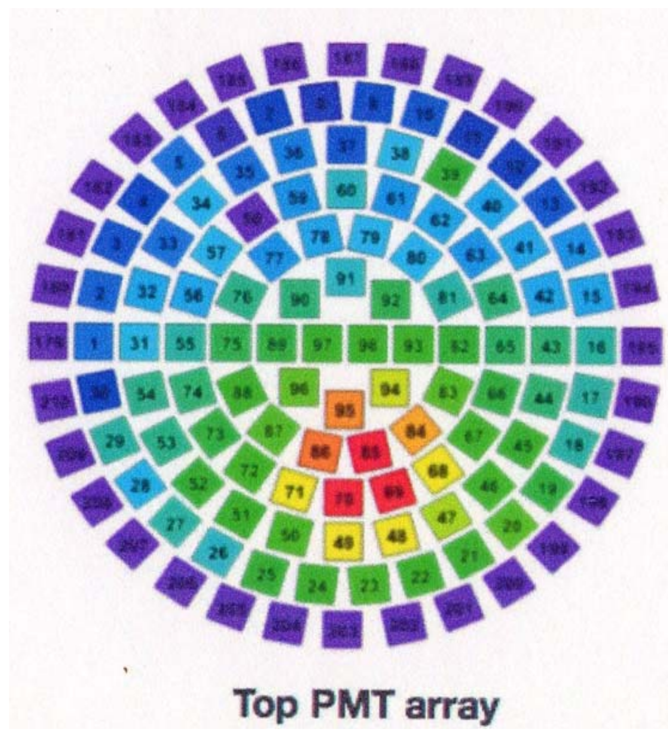
PANDA-X   Dark Matter Search

Excellent position resolution: 2 mm perp. to el. Field
1 mm along el. field

Mean free paths: MeV Gamma 3 cm
MeV Neutron 30 cm

XENON100





PANDA-X Dark Matter Search

Improvements over XENON100:

Less background due to deeper site

Multiple Gamma and Neutron events in larger detector

Better Gamma – Neutron band separation (higher E – Field)

Enhanced light collection

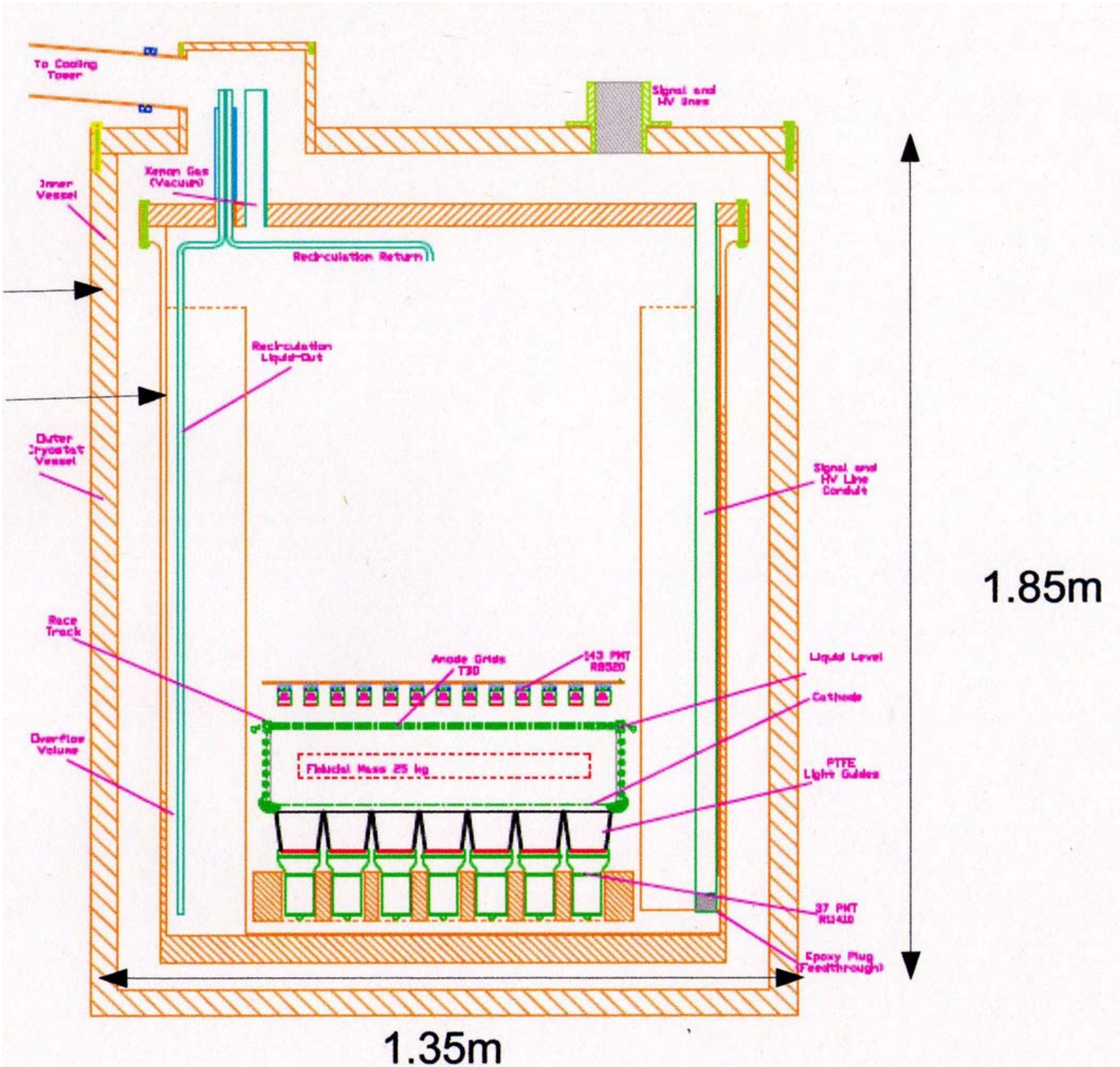
Reduced amount of Teflon

Larger distance of Bottom PMT to Active Volume

But,

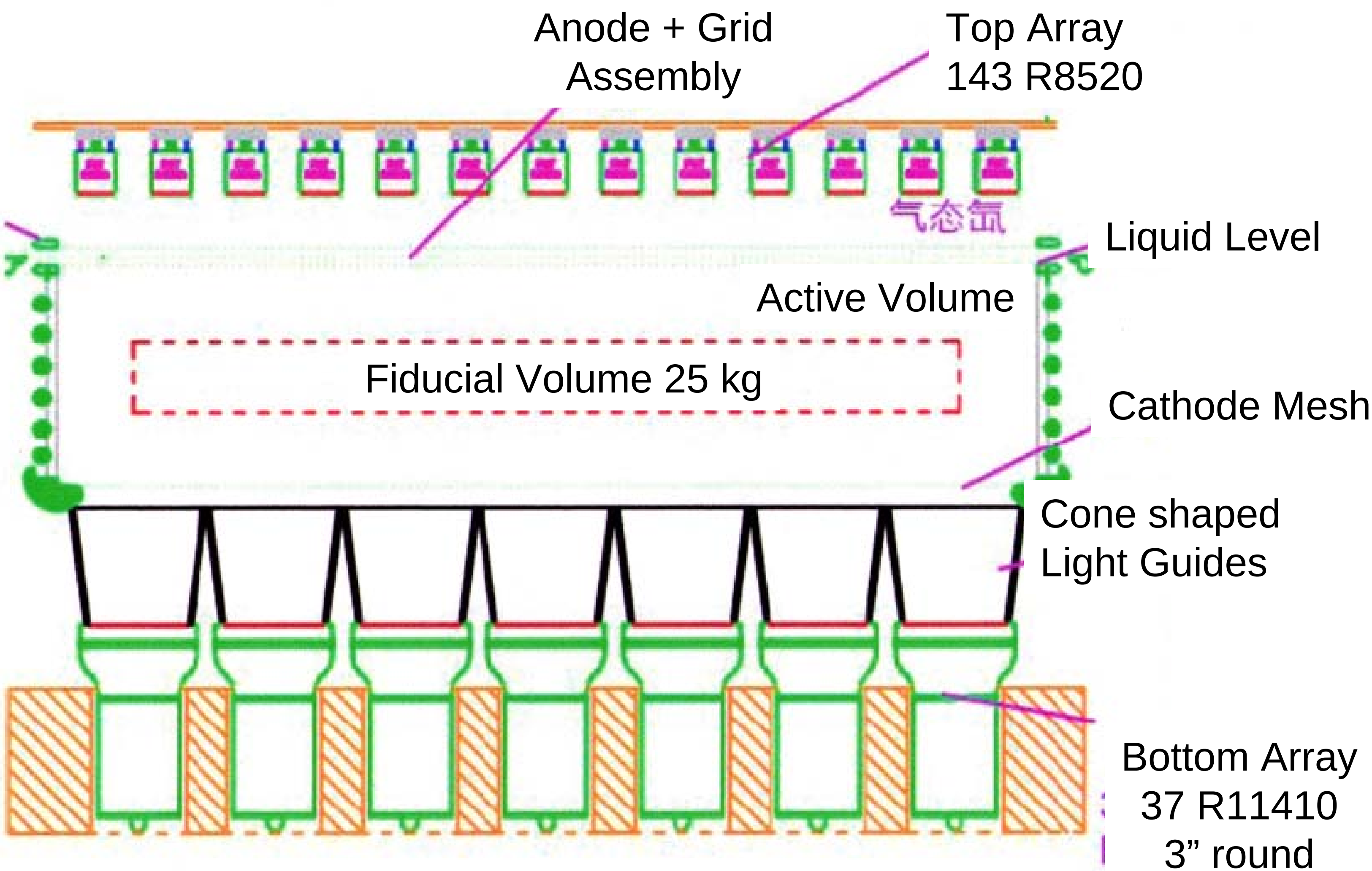
No active Veto

PANDA-X Dark Matter Search



PANDA-X Dark Matter Search

Schematic Lay out of the inner structure of Panda



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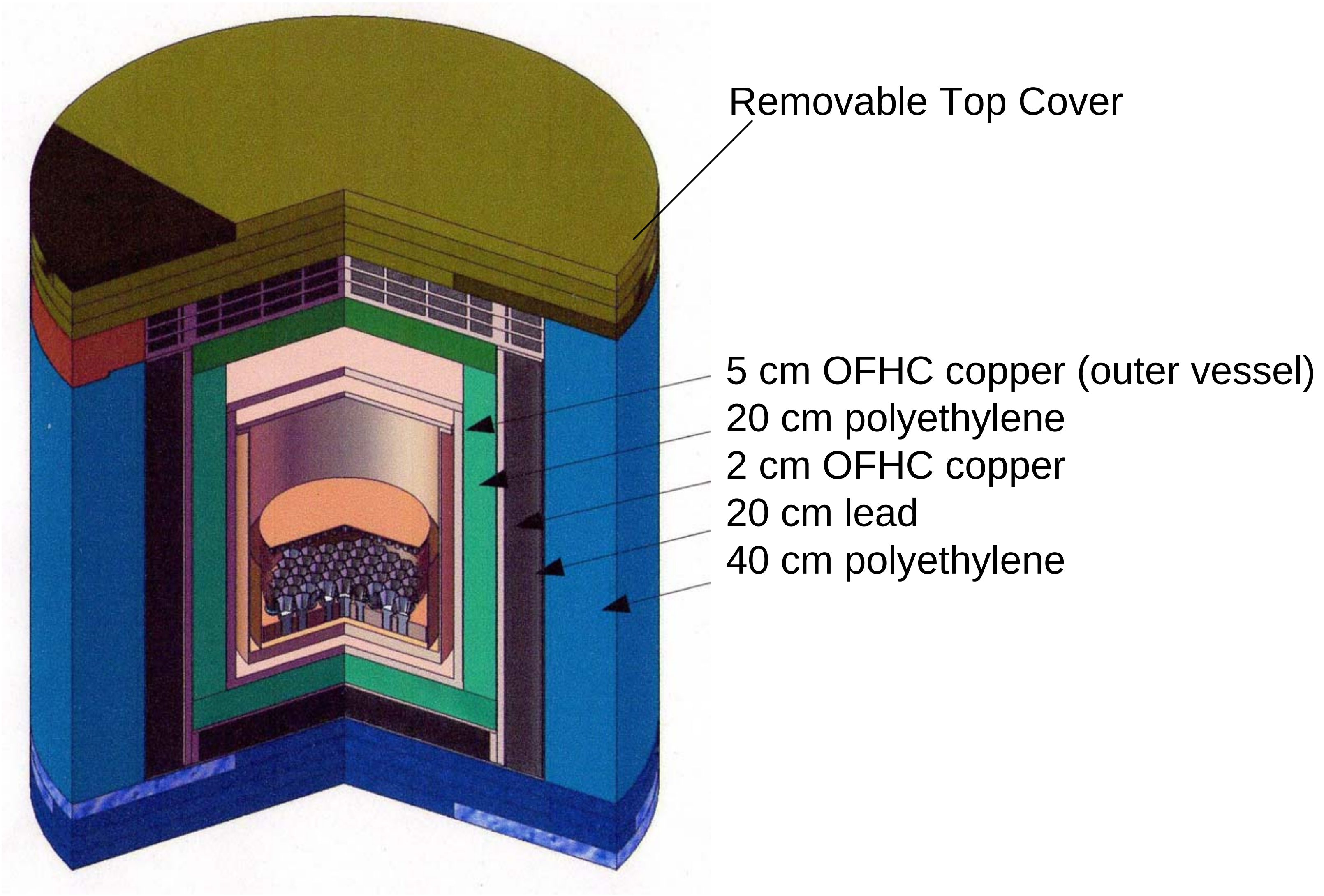
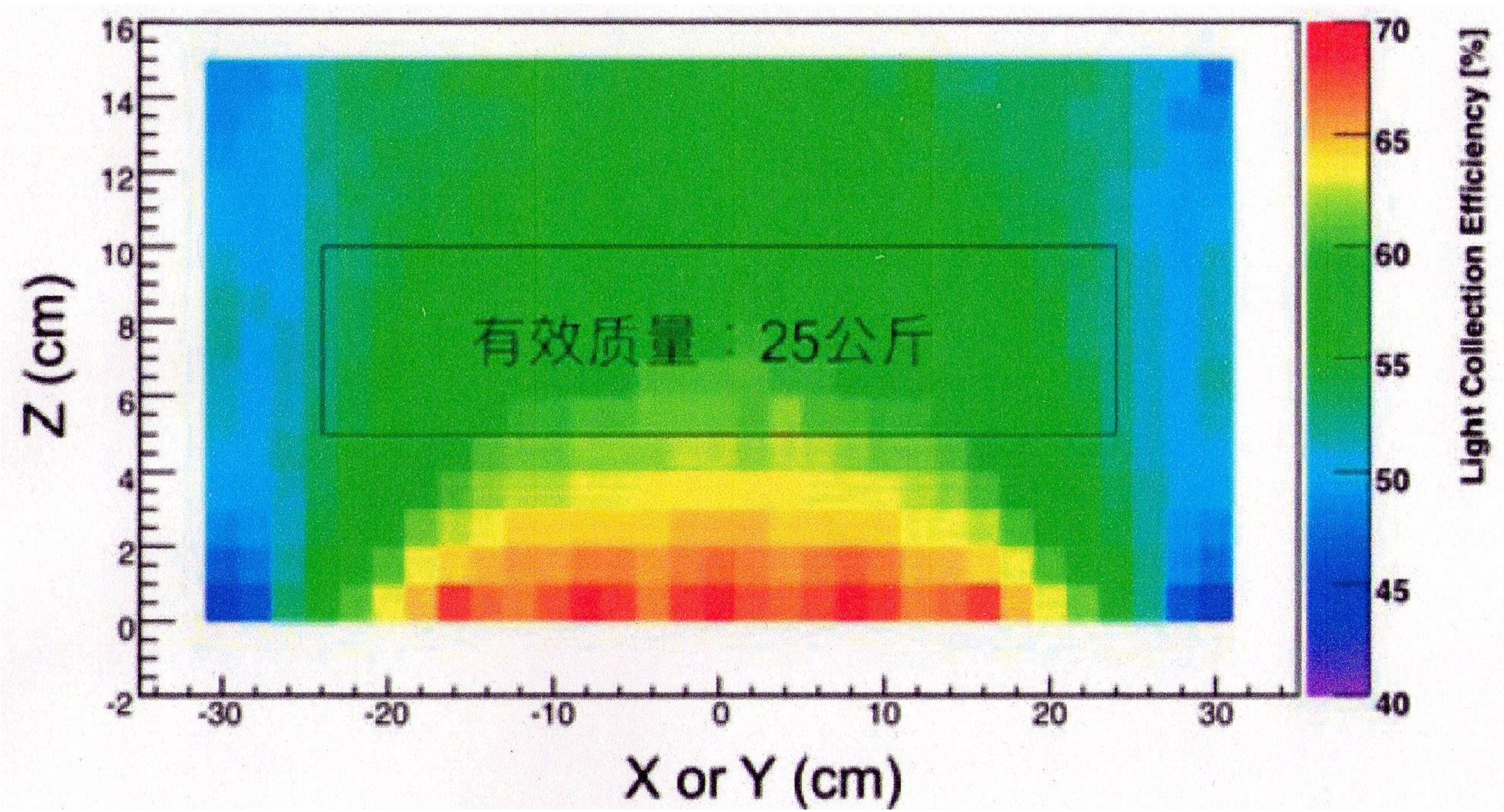
Panda in it's Shield



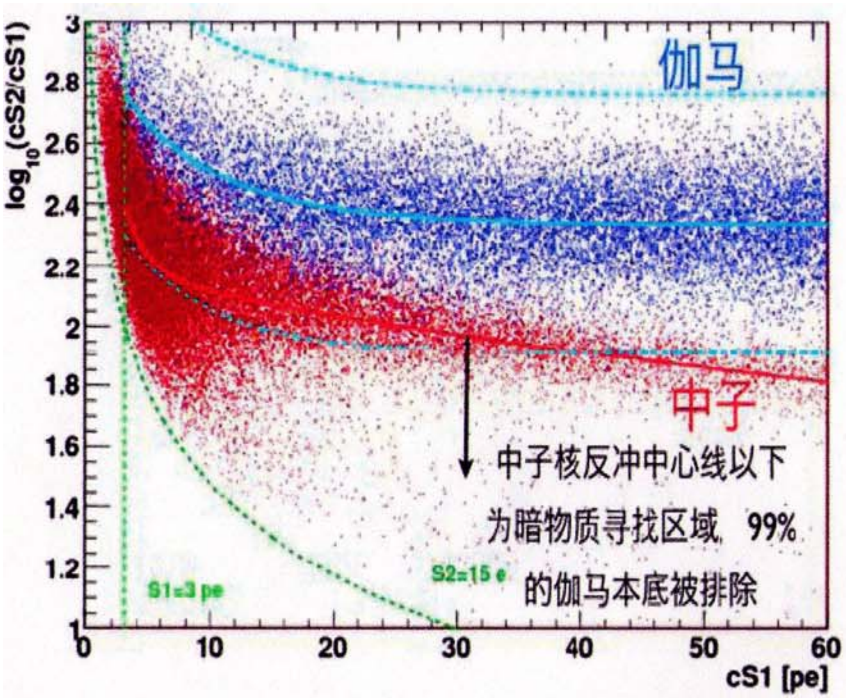
PANDA-X Dark Matter Search

Panda will have a high and uniform light collection efficiency



PANDA-X   Dark Matter Search

The high light collection efficiency at high fields assists in rejecting background



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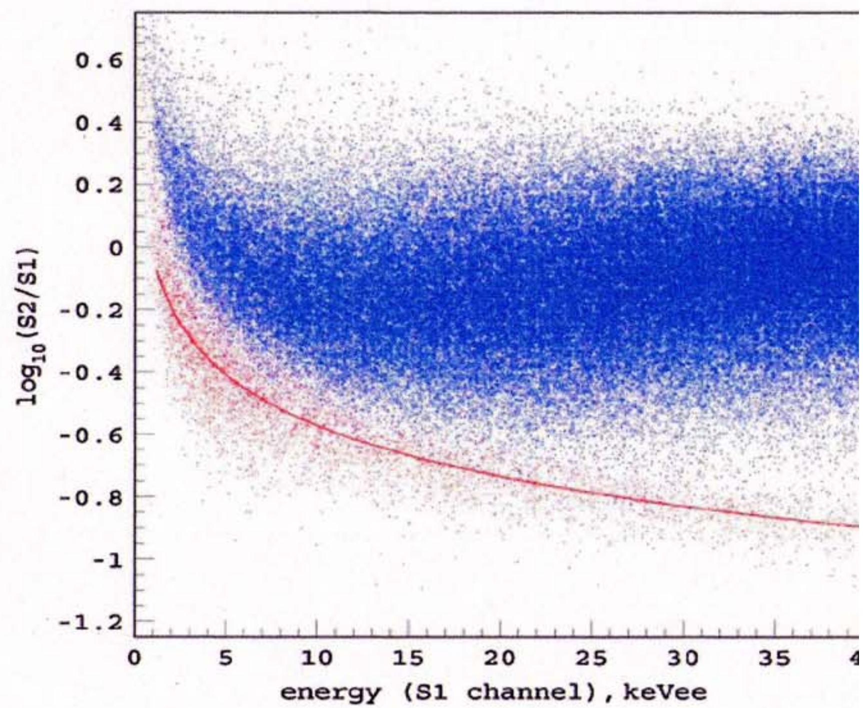

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PANDA-X Dark Matter Search

Comparison of Xenon based Experiments

	Zeplin III	XENON100	XMASS	LUX	PANDA-X
Fiducial Mass Total (kg) Fiducial (kg)	 12	 270 60	 800 100	 300	 120 25
Electron Recoil Rejection (%)	99.9	99	0	99	99.9
Energy Threshold (keVr)	10	9	20	10	5
Sensitivity at 100 GeV (cm^2) 10 GeV (cm^2)	 10^{-44} $>10^{-42}$	 2×10^{-45} 3×10^{-43}	 10^{-45} $>10^{-42}$	 3×10^{-46} 4×10^{-44}	 4×10^{-45} 10^{-44}
Status	Science Run	Science Run	Operation	Surface Testing	Construction

PANDA-X Dark Matter Search

Schedule:

Civil engineering of underground lab completed

Major items ordered, incl. the vessels, cryogenic system, read out electronics, PMTs

Most of the equipment is expected before end of March

Above ground lab at SJTU preparation nearly completed

Above ground tests of complete set up to start in June

Installation of shield underground to start end of March

Counting facility to be assembled before end of March

Underground installation of detector: September

PANDA-X Dark Matter Search

SJTU only recently started with xenon technology. A year ago rather few of infrastructure existed. In the mean time:

Equipped a lab for the development of Panda.

Set up a machine shop to support our activities

Built small test system

Set up gas supply system and recirculation for high flow rates

Set up PMT test facility

Started development of Kr removal column

Started development of Read Out system

Started develpment of counting facility in Jin Ping lab

PANDA-X Dark Matter Search

Some of the recent activities: